ECOLOGY, REPRODUCTIVE BIOLOGY AND HORMONAL CONTROL OF REPRODUCTION IN THE FEMALE SPINY LOBSTER *PANULIRUS HOMARUS* (LINNAEUS 1758).

Student: **R.Thangaraja**, Research Scholar, CMFRI.

Subject: **Biosciences**

Reg. No: CR-156/2003-04/A3

Department of Bioscience, Mangalore University,

Guide: **Dr.E.V.Radhakrishnan**, Principal Scientist & Head, CFD, CMFRI, Kochi.

FINAL SYNOPSIS

Fishery biology and Ecology:

Ecology of spiny lobster fishing grounds on the southwest and southeast coast of India was studied by conducting field survey at two major lobster landing centers, one in Chinnamuttom located on the southeast coast and another in Khadiyapatanam, located on the southwest coast of India. Monitoring of lobster fishery was carried out following the Stratified Random Sampling Design developed by CMFRI. Lobster fishery is seasonal, beginning from September and ending in March at Khadiyapatanam on the southwest coast and in Chinnamuttom on the southeast coast. However, the peak season of lobster fishery is from October to January on both the coasts. Lobster fishery, biological details of lobsters and composition of associated fauna were estimated during the fishery (October-January) and non fishery season (April-May) on both the coasts. The ecological study was carried out during the peak fishery period (October-November 2006) in Khadiyapatanam and Chinnamuttom coasts and also during non fishery season (April-May 2007). The fishery biomass from eight randomly selected Bottom Set Gill Nets (BSGN) and the hydrobiological parameters from both the lobster fishing areas were collected and estimated. At Khadiyapatanam during October the average total biomass landed per day per net was estimated to be 3961.8 g. Lobsters contributed 1596.25 g forming 42% of total biomass landed. The estimated associated fauna was 1819.38 g (45%) and the associated flora including sea grass and sea weeds 546.25 g (13%). During November average total biomass landed per day per net was estimated to be 6014.37 g. Lobsters

contributed 1395.62 g forming 23.20% of total biomass landed. The associated fauna was an estimated 3466.25g (57.63%) and the associated flora including sea grass and sea weeds 1152.5 g (19.16%). In the Chinnamuttom fishing ground, the average biomass landed per day per net was 7142.5 g, during October in which lobsters constituted 1033.13g forming 14 % of total biomass. Associated fauna was to the tune of 2409.38g (33.73%) and the associated flora including sea grass and sea weeds contributed 3698.7g (51.7%). During November, average biomass landed per day per net was 6849.38 g, in which lobsters contributed 914.12 g forming 13.34% of total biomass. Associated fauna was to the tune of 2654.25 g (38.75%) and the associated flora including sea grass and sea weeds contributed 3281 g (47.90%). This shows that Khadiyapatanam is a richer fishing ground for lobsters compared to Chinnamuttom.

The morphological measurements, carapace length (CL) and total length (TL) were measured with a vernier caliper and a scale respectively to the nearest 0.1mm. The average body weight (W) of a lobster caught in a BSGN operated at Khadiyapatanam during October was 170.29 g with a total length (TL) of 172.06 mm. The average carapace length (CL) was 55.89 mm. Females constituted 53.33% and 45 % of females landed were sexually mature and 17.5% in berried stage. Three species were recorded and the species composition during this month was *P.homarus (*96%), *P.ornatus* (2.66%) and *P.versicolor* (1.33%). An averages of 80 BSGN were operated per day and the total landing in October was estimated to be 3180kg with a CPUE of 1.59kg considering 25 fishing day/month.

During November average body weight (W) of a lobster caught in a BSGN operated in Khadiyapatanam was 251.16 g with a total length (TL) of 195.55 mm. The average carapace length (CL) was 62.76 mm. Females constituted 54.16% and 61.53 % of females landed were sexually mature and 15% were in berried stage. Three species were recorded and the species composition during this month was *P.homarus* (95.83%), *P.ornatus* (2.08%) and *P.versicolor* (2.08%) respectively. The total monthly landing in Khadiyapatanam was estimated as 2780kg with the catch per unit effort of 1.39kg/day. During December and January the monthly landing was 1665kg with CPUE of 1.11kg/unit/day and 935kg with a CPUE of 0.68kg/unit/day respectively.

At Chinnamuttom, the average body weight (W) of a lobster caught in a BSGN was 152.97 g, with the total length (TL) measuring 164.40 mm and carapace length (CL) 57.03mm.

In the total catch, 51.85% were females and 26% were sexually matured and 3% of the female lobsters were in berried stage. The average quantity of lobsters caught (CPUE) in Chinnamuttom coast was 1.03 kg per unit/day. By operating an average 45 nets per day, the total estimated monthly landing in October was 1158.75kg in 25 fishing days.

During November the average body weight (W) of a lobster caught in a BSGN was 197.64 g, with the total length (TL) measuring 180.14 mm and carapace length (CL) 57.48 mm. 56.75% were females and 21.42% were matured females, 16.66% of the female lobsters were in berried condition. The species composition during November was 89.18% *P.homarus*, 5.40% of *P.ornatus* and *P.longipes* and 2.70% of *P.versicolor*.By operating an average 45 nets per day, the total estimated monthly landing in November was 1032.75kg with a CPUE of 0.91kg/unit/day. Monthly landing estimates during the month of December 2006 and January 2007 were estimated as 715kg with a CPUE of 0.715 kg/unit/day and 422.25kg with a CPUE of 0.563 kg/unit/day with an average of 40 and 30 nets respectively from 25 fishing days/month.

During non fishery season (April-May) at Khadiyapatanam the average total biomass landed was 5090.62g and lobsters found was 143.75g (2.82%) during April and 4130g of biomass lobsters were 66.25g (1.89%).At Chinnamuttom the average landing had 8850g of total biomass with 233.75g (2.64%) of lobsters during April and 8271.25g of biomass with 126.25g (1.52%) of lobsters landed in BSGN at both the coast the average CPUE was less than 0.3 kg/unit/day in May.

Species Diversity:

Shannon-Wiener species Diversity Index for lobster species in both Khadiyapatanam and Chinnamuttom during the peak fishery season (October and November) was calculated using the software PRIMER 0.5. Shannon species diversity in Khadiyapatanam showed species richness (d) 0.4604, eveness (J') 0.2197 and the species diversity (H') 0.1043 during October and in November the species richness (d) is 0.5112, eveness (J') 0.3042 and the species diversity (H') was 0.1452. At Chinnamuttom the species richness (d) during the month of October was 0.5037, eveness (J') 0.2308 and the species diversity (H') 0.1101 and during November the species richness (d) was 0.8308, eveness (J') 0.2339 and the species diversity (H') 0.2523 Species richness of lobsters and the diversity was higher during November at Chinnamuttom

than october and also than the Khadiyapatanam ground. A total of 3 species of spiny lobsters were found in Khadiyapatanam fishing ground during October and November, whereas in Chinnamuttom 3 species during October and 4 species during November were found

Hydrography

Hydrobiological parameters in the lobster fishing grounds during October-November 2006 and April-May 2007 were collected and analysed following standard analytical procedures. During the survey seawater samples were collected from the bottom and surface at each randomly selected stations at both Khadiyapatanam and Chinnamuttom coasts. Geo-reference of each station was marked using Global Positioning System (GPS). Depth of the fishing ground, temperature, salinity, DO, BOD, $N0_2$, NO_3, PO_4, SiO_3, Chlorophyll pigments, organic carbon and the soil texture were estimated. At Khadiyapatanam the average depth of BSGN operating ground in the eight stations was 10.6m. Mean values of bottom hydrological parameters during October 2006 are: salinity 34.25 ppt, pH 7.97, the bottom temperature of sea water, 28.7°C, dissolved oxygen level 4.66 ml/l, the Biological Oxygen Demand 1.317 ml/l. The mean visibility (Seechi disc reading) was 7.2m. The Total Suspended Solids (TSS) was 46.45 mg/l, the Chlorophyll pigment concentration 0.076 mg/m^3, the NO_3 level was 0.0760 µ mol/l, the $N0_2$ level 0.0435 µ mol/l, the phosphate (PO_4) level was 1.35 µ mol/l and the SiO_3 level in Khadiyapatanam lobster ground was 4.14 µ at/l and the ammonia level was 0.011µ mol/l. Mean values of bottom hydrological parameters during November 2006 are: salinity 34.17 ppt, pH 7.9 , the bottom temperature of sea water, 27.9°C, dissolved oxygen level 4.56 ml/l, the Biological Oxygen Demand 1.31 ml/l. The mean visibility was 7.2m. The Total Suspended Solids (TSS) was 39.52 mg/l, the Chlorophyll pigment concentration 1.245 mg/m^3, the NO_3 level was 0.075 µ mol/l, the $N0_2$ level 0.032 µ mol/l, the phosphate (PO_4) level was 0.66 µ mol/l and the SiO_3 level in Khadiyapatanam lobster ground was 00.037 µ at/l and the ammonia level was 0.025µ mol/l. On the otherhand, On the otherhand, at Chinnamuttom lobster fishing ground the average depth of BSGN operating ground in the eight stations was 6.72m. Mean salinity was 34ppt, pH 7.92, the temperature of bottom sea water, 28.52°C, dissolved oxygen level 4.6ml/l, the Biological Oxygen Demand 0.982ml/l, visibility 3.4m, Total Suspended Solids (TSS) was estimated to be 81mg/l, the chlorophyll pigment concentration in 0.878mg/m^3, the NO_3 level 0.0530 µ mol/l, the $N0_2$ level 0.0460 µ mol/l, the PO_4 1.383 µ mol/l and the SiO_3 level 4.24 µ

at/l. Mean values of bottom hydrological parameters in Chinnamuttom during November 2006 are: salinity 34.24 ppt, pH 7.9 , the bottom temperature of sea water, 27.25°C, dissolved oxygen level 4.67 ml/l, the Biological Oxygen Demand 0.915 ml/l. The mean visibility was 3.9m. The Total Suspended Solids (TSS) was 51.11 mg/l, the Chlorophyll pigment concentration 0.793 mg/m^3, the NO_3 level 0.075 µ mol/l, the $N0_2$ level 0.079 µ mol/l, the phosphate (PO_4) level 1.481 µ mol/l, SiO_3 level was 0.082 µ at/l and the ammonia level was 0.007µ mol/l.

Hydrobiological parameters in the sea surface water during October 2006 in the Khadiyapatanam were collected and analysed . Mean value of hydrobiological parameters are: salinity 34.06 ppt, temperature 28.7°C, DO level 4.66 ml/l, BOD 1.32 ml/l, pH 7.97. The Total Suspended Solids level was found to be 37.38 mg/l, whereas the chlorophyll pigment level was 0.126 mg/m^3 on an average. The average level of nutrients such as NO_3, NO_2 and PO_4 were 0.265, 0.252 and 0.831 µ mol/l respectively. The SiO_3 and ammonia levels were 0.83and 0.011 µ mol/l, respectively. Mean value of hydrobiological parameters during November 2006 are: salinity 34.25 ppt, temperature 28.71°C, DO level 4.95 ml/l, BOD 1.51 ml/l, pH 7.97. The Total Suspended Solids level was found to be 41.87 mg/l, whereas the chlorophyll pigment level was 0.723 mg/m^3 on an average. The average level of nutrients such as NO_3, NO_2 and PO_4 were 0.029, 0.022 and 1.138 µ mol/l, respectively. The SiO_3 and ammonia levels were 0.039 and 0.006 µ mol/l, respectively.

Sea surface hydrological parameters at Chinnamuttom coast during October 2006 at selected stations were estimated. Mean value of hydrological parameters are: salinity 34.0ppt, the temperature 28.08°C, the DO level 4.97 ml/l, BOD level was 0.98ml/l and the average pH was found to be 8.0. The Total Suspended Solids (TSS) was found to be 46.06mg/l and the Chlorophyll level was 1.195 mg/m^3. The average level of nutrients such as NO_3, NO_2 and PO_4 were 0.059, 0.062 and 01.334 µmol/l respectively. The SiO_3 and NH_3 levels were 0.081 and 0.012µmol/l.

Khadiyapatanam, the soil texture study showed 89% of sand in station 1 and it was the minimum level amoung 8 stations, the maximum sand component was found 94% in station 8, stations 4 and 6 had only rocky substratum. The clay component was 0% in 4 and 6. Station 1 had 9% of clay, station 2 and 3 had 7%, station 5 had 9%, station 7 and 8 had 6% and 5%, respectively. The silt component in station 2,4,5,6 are found 0%, station 1 had 2%, station 3 had

1%, stations 7and 8 had 3%, 1%, respectively in Khadiyapatanam lobster fishing ground. The average soil texture profile found at Khadiyapatanam during the study period October-November 2006 was 90% sand, 8% of clay and 1-2% of silt. At Chinnamuttom lobster ground, the soil texture study showed sand component as 91% in stations 1,5 and 7. At stations 2,3,8 had 92% of sand, the station 4 had 86% of sand and the station 6 had 93%. The clay component was 7% in stations 2, 3 and 8 and it was 6% in stations 6 and 7. Station 1 had 8%, station 4 had 12% and the station 5 had 9%. The silt component in the soil was 1% in stations 1,2,6 and 8 station 5 had 0% of silt, stations 4 and 7 had 2% and 3%, respectively. The average soil texture profile found at Chinnamuttom during the study period October-November 2006 was also found 90% sand, 8% of clay and 1-2% of silt. Since lobsters are bottom living organisms, its distribution depends on bottom substratum. It prefers rocky substratum with above mentioned soil texture that support their movement, feeding and shelter. The mussel *Perna indica* beds on the rocks is the major food for spiny lobsters and their abundance is closely related to lobster abundance. The organic carbon level found in the Khadiyapatanam sea floor was 0.13% in station 1, 0.23 % in station 2, 0.085 in station 3, station 5 had 0.278%, the station 7 and 8 had 0.16% and 0.14%, respectively.The average level found during November was 0.17% in the same stations of the Khadiyapatanam fishing ground. On the other hand the Chinnamuttom in the southeast coast had 0.21% in station 1, 0.135% in station 2, 0.05% in station 3 , 0.04% in station 4, 0.165% in station 5, 0.06% in station 6, the organic carbon in the soil was found 0.15 and 0.13% in stations 7 and 8, respectively. The average organic carbon level during November was 0.22% in ChinnamuttomThe organic carbon level refers the nutrient status of soil and also the productivity of particular region.

The associated fauna and flora caught in the net belongs to 10 species of fin fishes, five species of crustaceans including crabs, four species of molluscs, five species of echinoderms, 11 species of sponges, and 13 species of sea weeds in Khadiyapatanam and in Chinnamuttom 9 species of finfishes, six species of crustaceans, four species of molluscs, 5 species of echinoderms , 15 species of sponges and 21 species of sea weeds were recorded from the BSGN operated in the lobster fishing grounds.

During the non fishery season during May 2007 in Khadiyapatanam, the mean value of sea bottom hydrological parameters are: salinity of sea water 34.72ppt, temperature 29.5°C ,

dissolved oxygen 4.52 ml/l, Biological Oxygen Demand 1.3ml/l, pH 7.9, light penetration 7.2 m Total Dissolved Solids, 60.06 mg/l. The chlorophyll pigment concentration was 0.103 mg/m^3. The nutrients such as NO_3, $N0_2$ and PO_4 were with an average of 0.037 µ mol/l, 0.097 µ mol/l and 1.409 µmol/l, respectively. The average SiO_3 level was found 0.28 µgat/l. the ammonia level was found to be 0.006µmol/l during the non fishing period in May 2007. Mean values of bottom hydrological parameters during April 2007 are: salinity 34.6 ppt, pH 7.9, the bottom temperature of sea water, 30.58°C, dissolved oxygen level 4.58 ml/l, the Biological Oxygen Demand 0.88 ml/l. The mean visibility was 6.75 m. The Total Suspended Solids (TSS) was 78.66 mg/l, the Chlorophyll pigment concentration 0.57 mg/m^3, the NO_3 level was 0.124 µ mol/l, the $N0_2$ level 0.031 µ mol/l, the phosphate (PO_4) level was 0.984 µ mol/l and the SiO_3 level was 0.070 µ at/l and the ammonia level was 0.009µ mol/l. Meanwhile in the Chinnamuttom coast during the non fishery season, the mean value of hydrobiological parameters of sea bottom are: salinity 34.68, temperature 30.25°C, Dissolved Oxygen level 4.57 ml/l , Biological Oxygen Demand 0.90 ml/l, pH 7.9, light penetration 3.9 m depth and while the average Total Dissolved Solids 47.86 mg/l. The chlorophyll pigment concentration was 0.863 Mg/m^3. The nutrients such as NO_3, $N0_2$ and PO_4 were with an average of 0.0903 µmol/l, 0.0476 µmol/l and 1.2106 µmol/l, respectively. The average SiO_3 level was found 0.243 µgat/l, the ammonia level was found 0.0065 µmol/l .The mean value of hydrobiological parameters of sea bottom during April 2007 are: salinity 34.68, temperature 30.48°C, Dissolved Oxygen level 4.54 ml/l, Biological Oxygen Demand 0.79 ml/l, pH 7.9, light penetration 3.9 m depth and while the average Total Dissolved Solids 47.85 mg/l. The chlorophyll pigment concentration was 0.863 mg/m^3. The nutrients such as NO_3, $N0_2$ and PO_4 were with an average of 0.128 µmol/l, 0.132 µmol/l and 0.395 µmol/l, respectively. The average SiO_3 level was found 0.044 µgat/l, the ammonia level was found 0.007 µmol/l during the non fishing period.

The wind pattern, ocean surface current, surface temperature and chlorophyll pigment concentration were obtained from satellite data provided by ocean motion data base. (http://oceanmotion.org/html/resources/oscar.htm) and they were correlated with the lobster fishery during the peak season (October-November2006 on the southwest coast and the southeast coast. Meanwhile the weather status during non fishery season (April-May 2007) in the south

west coast and south east coast were also related to study the influence of ocean weather on lobster fishery.

On the southwest coast, the ocean current was found to be towards the north direction during the peak fishery season (October-November 2006). The wind pattern was also found to be towards east, i.e. towards leeward direction in south west coast. The sea surface temperature was between 28 and 29°C, chlorophyll pigment concentration was found to be from 0.1 to 1 mg/m^2. The lobster catch during this period was found to be 1.59 kg/ unit effort.

On the southeast coast, the peak fishing season is during October-January and during these months ocean current was found to be in southeast direction and the water moves eastwards turning towards northeast direction. The ocean wind pattern was found towards east direction. The sea surface temperature was found between 28 and 29°C and the chlorophyll pigment concentration was found 0.1 to 1 mg/m^2. The lobster catch during this period was found to be 1.03 kg/unit effort.

During non-fishery season (April- May) on the southwest coast the ocean current was towards south direction (southwest coast) during the ocean wind pattern was found towards east and it was leeward. The sea surface temperature was found between 30 and 31°C, chlorophyll pigment concentration was found ranging from 0.1 to 1 mg/m^2. The lobster catch during this period was found less than 0.2 kg/ unit effort and there was no lobster fishing was observed during this period.

During non-fishery season (April- May) in the southeast coast the ocean current was towards southwest direction in the Chinnamuttom area (southeast coast). The wind pattern was found towards north direction in southeast coast, the sea surface temperature was between 30 and 31°C, chlorophyll pigment concentration was found ranging 0.1 to 1 mg/m^2. The lobster catch during this period was found almost nil and no operation of lobster net was observed during this period.

Observation of sea bottom in Khadiyapatanam near the shallow shore region using transect survey showed 43.5% of barnacles, turfing algae 12%,mussels10 %, Sponges 10%, sand and rubbles 12.5%.

At Khadiyapatanam peak fishery for lobster and the brown mussel *Perna indica* is closely related. The harvest of brown mussels in Khadiyapatanam starts during November and extend up to January. Higher abundance of lobsters at Khadiyapatanam than at Chinnamuttom may be due to some factors like physical topography of bottom habitat and availability of preferred food. The co-existence of lobsters and mussels in the fishing ground indicate that abundance of lobsters is closely related to the availability of mussel. *P.homarus* is gregarious in habit and the rocky substratum and the reefs in Khadiyapatanam provide plenty of shelter. In Chinnamuttom the bottom substrate was constituted with calcareous and rocky reefs. But the extent of rocky reefs is lesser than Khadiyapatanam. Hence landing estimate show higher biomass (lobster 1.6 kg/unit/day) in Khadiyapatanam compared to 1.03kg/unit/day in Chinnamuttom.

Food preference of *P.homarus*:

To identify the preferred food of *P.homarus* in the Khadiyapatanam lobster ground gut analysis was carried out. The gut content of spiny lobster *Panulirus homarus* was estimated by collecting 24 lobsters with the carapace length measuring 50-60 mm. The animals were immediately freeze killed after landing at Khadiyapatanam coast and the animals were dissected to separate the gut for analysis. The total content was weighted in a digital balance before separating. The feed categories were sorted out under a dissection microscope and each category of feed components were separated and weighed. The quantity of categorized feed materials from the foregut were separated, which includes mollusks shell pieces, crustaceans, algae, polychaetes, and unidentified others, which includes semi digested materials and sediments ect.

Broken shells of the mussel *Perna indica* and others constituted 33.0% crustaceans (14.24%), algae (8.78%), polycheates (8.15%), and 35.2 % were unidentified materials such as algal and semi-digested materials.

Associated fauna in the lobster fishing ground:

The bottom topography and the benthic ecology, especially wide-spread beds of the brown mussel *Perna indica*, probably influence the abundance of *P. homarus* at Khadiyapatnam ground.The Average percentage wise contribution of associated fauna in BSGN at Khadiyapatanam lobster ground showed 21.8% of fishes, 18.04% of crustaceans, 13.9 % of

mollucs, 22.44% sponges and 23.66 % of echinoderms during October. During November it was 14.94% of fishes, 20.18% of crustaceans, 3.49% of mollusks, 13.725% of sponges and 47.62% of echinoderms. The average composition during December and January was 28.84% fishes, 23.25% crustaceans, 21.13% mollusks, 12.24% sponges and 21.9% echinoderms. At Chinnamuttom coast the associated fauna composition was 34.55% fishes, 25.65% crustaceans, 10.84% mollusks, 9.02% sponges and 19.81% of echinoderms. During November 29.38% fishes, 36.54% crustaceans, 11.46% mollusks, 9.34% sponges and 13.25% echinoderms. The average composition during December and January was 24.26% fishes, 40.25%crustaceans, 11.73% mollusks, 14.74% sponges and 12.1% echinoderms during fishery season.

The major groups of organisms in the fishing ground are echinoderm, fishes, sponges, crustaceans and molluscs. Monitoring of the associated fauna landed along with the lobsters also show changes in faunal composition between the fishing and non-fishing periods with echinoderms, mostly seaurchins and seastars constituting 33% of the total associated fauna during October-November and 4.7 % during April-May.

During non-fishery season April and May at Khadiyapatanam the average associated fauna composition was 45.5% fishes, 23% crustaceans, 17% mollusks, 10% sponges and 4.5% echinoderms. And at Chinnamuttom it was 34% fishes, 31.91% crustaceans, 12% mollusks, 16.24% sponges and 4.17 % echinoderms. The major contribution was fishes followed by crustaceans and the echinoderms were the least of below 5% but during fishery season October to December it was above 12%. This shows similar trend of echinoderm contribution in the both coast.

Morphometric relationship :

The morphometric parameters such as carapace length (CL), total length (TL) and Total weight (W) was analysed and the relationship between each parameter was compared. The relationship between the growth parameters were estimated based on the equation $Y=aX^b$ where X and Y are interdependent parameters The coefficients, a and b of the power function described above was estimated from the experimental data using the curve elimination option available in the Staticial Package for Social Scientist (SPSS) Version 14. The equations for estimating the morphometric relationship are as follows:

- The relationship of total length (TL) with the carapace length (CL) was estimated using the equation $TL=a\ CL^b$ ($TL = 2.691 \times CL^{1.009}$) for the female lobsters and for male $TL = a\ CL^b$ ($TL = 3.566 \times CL^{0.928}$) .

- The relationship of Total weight (W) with the carapace length (CL) was estimated using similar power function. The growth rate of Total weight (W) in relation with the carapace length (CL) was estimated using the equation $W=a\ CL^b$ ($W = 0.001 \times CL^{3.030}$) for female lobsters and for male $W = a\ CL^b$ ($W = 0.001 \times CL^{2.906}$).

- The relationship of Total weight (W) with the total length (TL) was estimated using similar power function. The growth rate of Total weight (W) in relation with the carapace length (TL) was estimated using the equation $W=a\ TL^b$ ($W = 5.84E\text{-}005 \times TL^{2.943}$) for female lobsters and for male $W = a\ TL^b$ ($W = 3.13E\text{-}005 \times TL^{3.078}$).

- The relationship of third walking leg (III WL) with the carapace length (CL) was estimated using the equation $III\ WL = a\ CL^b$ ($III\ WL = 2.047 \times CL^{0.973}$) for the female and for male $IIIWL = 1.003 \times CL^{1.170}$) and the growth parameters between sexes were compared.

Reproductive biology

Studies on reproductive biology of the female spiny lobster *Panulirus homarus* was carried out with main emphasis on the development of primary and secondary sexual organs. The development of secondary sexual characters in female spiny lobsters such as endopod setae and 'windows' were correlated with ovarian maturity indices. Female lobsters from the fishery were examined for presence of spermatophoric mass and presence of eggs on the pleopods as these are considered as external indicators of female maturity in *P. homarus*. Setal development on endopods as an indicator of maturity is proposed in this study as sudden increase in length of endopod setae after a moult was noticed and this moult may be called as maturity moult. The development of endopod setae was studied by observing the setal length from the first pair of endopods in the female *P. homarus*. The appearance of endopod setae was noticed in the lobsters above 20 mm and the setae at immature stage was 1-2 mm in length and it reached 10-12 mm at 55-60 mm carapace length. The gonadosomatic index increased from 0.6± 0.1 in lobsters measuring an average 49 mm CL (immature) to 0.9 ± 0.2 in lobster measuring an

average 63.3 mm CL (mature). In *P.homarus* 50% of females attained Sexual maturity at a carapace length of 60 mm and the endopod setae was measured as 12 mm. Therefore lobsters with endopod setae 12 mm and above may be considered as sexually mature. The length of setae increases further with each moult and helps the female in accommodating more eggs, which can be corroborated from the carapace length-fecundity relationship. The study shows that external indices such as length of endopod setae may be used as indicator of sexual maturity in female lobsters. The fecundity of Female *P.homarus* in relation with the carapace length had high significance (R2=0.9842). The increase in number of eggs in spawned berried females increases with the increasing carapace length (CL). The fecundity ranges from 85,000 in lobsters with 58mm carapace length and extended up to 900000 in the female lobsters with the carapace length of 83 mm respectively. The appearance of cement gland in the endopodite of pleopod in matured female also indicates the female maturity, whereas in immature female *P.homarus* cement gland was undeveloped.

Hormonal control of reproduction:

Experiments on hormonal control of reproduction in the female spiny lobster *P. homarus* were carried out by eyestalk ablation in female lobsters. Eyestalk is known to harbour moult inhibiting and gonad inhibiting hormones in the x-organ-sinus gland complex. The effect of eyestalk ablation on gonadal maturation was intended to study the role of the reproductive hormone in ovarian maturity. Experimental animals were collected from the landing centre and it was transported to CMFRI, Cochin in live condition and they were used for the present study.

An average 10 protein bands were observed in the haemolymph of unablated maturing female (control) which were resolved between 0-200 pixel positions with 50 pixel intensity on an average. The band resolved at 250 pixel position had high intensity followed by bands in 440 which also had intensity around 150 on an average. Only 2 to 3 bands were rarely observed between 250-400 pixel intensities. The low molecular proteins were resolved between 0-200 pixel positions. The expression of proteins at this range was very low.

An average of 13 protein bands were found expressed in the haemolymph of unilateral ablated group of female lobsters compared to the control group 72 hours after ablation.. There were 3 new proteins expressed between 100-200 pixel positions in unilateral ablated lobsters

which probably indicate the mobilization of vitellogenin (The protein responsible for yolk development in the egg) due to activation of VSH. The appearance of vitellogenin in haemolymph is probably due to decreasing titer of GIH consequent up on ablation. In the control animals the intensity of those proteins was expressed in few animals with less intensity (50 pixel intensity) between 100- 200 pixel position, meanwhile the intensity of those proteins are about 100- 150 pixels in the ablated animals. Mobilization of vitellogenin to the ovary probably was initiated 6-72 hours after ablation.

Haemolymph collected from experimental lobsters after 72 hours of unilaterally eyestalk ablation showed change in colour in comparison to normal animals. The change in colour is due to mobilization of orange coloured vitellogenin. The occurrence of new protein bands and increased titer of certain proteins shows that there is a factor in eyestalk that regulates the synthesis of vitellogenin. Female crustaceans are known to have a Female Specific Protein (FSP) which is the precursor lipoprotein responsible for synthesis of yolk proteins in the ovary (secondary vitellogenesis). Strong presence of vitellogenin in haemolymph indicates that the ovary is in the process of vitellogenesis. In ablated lobsters partial removal of GIH results in acceleration of gonad development and the vitellogenin in the haemolymph is probably mobilized from extraovarian sites and moving towards the ovary. In order to confirm the extraovarian source of vitellogenin, protein profile of hepatopancreas, ovary, haemolymph and adipose tissue of a maturing female was analysed. All the tissues showed the suspected vitellogenin indicating hepatopancreas and adipose tissue as the extraovarian site of synthesis of vitellogenin and haemolymph as the medium of transport from these sites to the ovary. The phenomenon was confirmed by protein profiling through native PAGE and by investigating the internal ovarian changes after 14 days of experimental period. The animals were sacrificed and ovary was dissected. The ovary stage was observed in both control and ablated animals. The ovary showed remarkable change in the development, ovary was coral red color showing accelerated ovarian development in the absence of gonad inhibiting hormone in the eyestalk. The average gonadosomatic index of control experimental lobsters was 0.6102 and in unilateral ablated experimental lobsters it was increased to 1.1162. On the other hand the average hepatosomatic index of control was 0.861 and was it found higher in unilateral experimental lobsters to 1.078. The average protein level of the ovary samples in normal animals was 43.34 mg/g while the experimental lobsters had 48.32 mg/g. Native PAGE showing the presence of

four identical protein bands in ovary and hepatopancreas between 60 to 65 kda and two identical bands were seen in heamolymph and ovary samples with the molecular weight between 20-29kda.This similarity of protein bands between the ovary, hepatopancreas and haemolymph reveals that synthesis of ovarian protein also takes place in hepatopancreas which is a extraovarian synthesis site for yolk protein in lobster as well as the mode of transportation was through haemolymph.

. In High Performance Liquid Chromatography analysis of ovary sample of unilateral ablated female spiny lobster *P.homarus* showed six peaks. Two major peaks, protein 3 and 4, was at 1.66 min and another at 1.942 min retained with the concentration of 66.92 and 27.99 % respectively. These two peaks might be the major ovarian yolk protein of lobsters found during the ovarian maturation. Other protein 1 resolved at 0.12 min, 5 resolved at 3.61min with 4.00% concentration and the sixth one resolved at 5.13min .Hence the major component of maturing ovary constitutes of yolk protein the major peaks observed were considered as ovarian yolk protein. At the same time haemolymph of maturing female *P.homarus* show 13 protein peaks Three major peaks were observed at 2.069, 2.150, 2.235 min with the concentration of 18.938,14.141 and 59.058% respectively. The second fraction of the HPLC sample retained at 1.797 min with the concentration of 2.792 % shows close retention time with the ovarian protein peak seen in the ovary sample

Hepatopancreas sample of maturing female lobster showed totally 8 fractions in HPLC analysis. Two major peaks were seen one at 1.620min and another at 1.940 min with the concentration of 9.268% and 90.283% respectively. The third peak which retained at 1.620 min closely coincide with the third peak of ovary sample and second fraction of haemolymph reveals that ovarian protein is synthesized in hepatopancreas and transported through haemolymph and deposited in the ovary. Hepatopancreas also is referred to as one of a yolk protein synthesis site in lobsters, by some workers.

Brief details of the thesis:

The research work of the proposed topic was compiled into a thesis with totally VI chapters. A general introduction which deals with the background information on past research work, aim of the research and the major objectives were included under **chapter I**. The **chapter II** deals with ecology and fishery of spiny lobster *Panulirus homarus* on the southwest and south east coast of India. The **chapter III** deals with Morphometric relationship of various morphological characters of both female and male spiny lobsters. The **chapter IV** deals with reproductive biology and hormonal control of reproduction in the female spiny Lobster *Panulirus homarus.* The **chapter V** consists of summary of the whole research outputs of the study conducted under the proposed topic and the **Chapter VI** consists of references of literature cited in the text. The introduction, review of literature, materials and methods, results and the discussion to each of the topic are included in respective **chapters II, III, and IV.**

(R. Thangaraja)
Research Scholar

Dr.E.V.Radhakrishnan, Ph.D
(The Supervising Guide)
Principal Scientist & Head, CFD,
Central Marine Fisheries Research Institute,
Cochin-18.